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## (54) IMPROVEMENTS RELATING TO PROJECTION SCREENS

(71) I, HIDEO SHIBAHARA, a Japanese citizen of 12-7, 1-chome, Wakagi, Itabashi-ku, Tokyo, Japan, do hereby declare the Invention, for which I pray that a Patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to projection screens, and more particularly relates to screens whose surface is constituted by a large number of optical units assembled to form a planar or curved surface.

Projection screens are already known which are provided with a lenticular surface in order to enhance reflection efficiency.

However these known reflection surfaces have poor selectivity with respect to incident light and their use is therefore restricted to darkened projection rooms or to outdoor situations after sundown.

Attempts have been made to overcome these disadvantages, but the prior proposals have encountered difficulty in overcoming the lack of selectivity to light reflection, and restriction to a constant narrow viewing angle.

Among the objects of this invention are to avoid the disadvantages noted above and to provide an improved projection screen which does not reflect surrounding light, is usable even when the surrounding area is bright, and possesses a wide viewing angle, and which can be used not only as a reflection screen for front viewing but also as a transmission screen for rear viewing. Further objects are to provide optical screen units which can be manufactured relatively easily and economically, and methods of making such screens.

More particularly, an object of this invention is to provide optical units composing a projection a screen, each unit having a convex lens surface of predetermined curvature and means for dispersing from a restricted area coaxial with said lens a selected portion of the projection light passing through said lens.

More particularly, the invention consists in an optical projection screen comprising a number of similar elementary surface units, each unit comprising a transparent body, the front surface of which forms a convex lens surface, light absorbing means associated with the rear surface of said units, and a discrete area of light dispersing material individual to each unit, said area being coaxial with the lens and of small dimensions relative to the maximum cross sectional area of the unit normal to the lens axis, the arrangement being such that, for each individual unit, of all the incident projected light, only those rays which are initially incident upon each convex lens along lines substantially parallel to the optical axis will, after refraction, or refraction and subsequent reflection, strike said light dispersing area, whereby substantially all of the light from the screen as seen by an observer is emitted from said small dispersing areas whilst incident light entering the units at other angles is either absorbed by the light absorbing means or, if internally reflected, does not strike the dispersing areas.

Advantageously, the thickness of said area of light dispersing material is many orders of magnitude less than the focal length of the convex lens surface and preferably consists of a thin film.

According to one preferred example of the invention said convex lens has a focal region situated within said unit on the lens optical axis and at or near the rear surface of said unit, the arrangement being such that light rays parallel to the optical axis are refracted to pass through said focal region and thereafter to strike directly said light dispersing area of the optical unit

situated adjacent said focal region.

Selectively in respect of projection light is obtained by masking means contacting substantially the whole of the rear surface of said unit except a restricted area coaxial with the lens axis in a position adjacent the focus region.

Furthermore the optical unit may include masking means covering at least one side surface of the unit extending substantially parallel to the optical axis of the lens.

In a particular embodiment the unit, apart from the convex lens surface, is substantially of parallelepiped form, with plane side faces arranged to make contact with the side faces of adjacent units when assembled on the screen face.

One such optical unit has a spherical convex lens surface and is of square section across the optical axis.

Another example of optical unit has a cylindrical convex lens surface and is of rectangular cross section with the major dimension of said rectangle parallel to the cylinder generatrix.

A front viewing optical unit may have a reflecting mirror on the optical axis adjacent the focal area of the lens, and a coaxial light dispersing area on the lens surface, said mirror reflecting selected rays of projected light back along said optical axis on to the dispersing area so that said dispersing area is visible from the projection side of the screen. The mirror may be a concave spherical mirror.

In a further example of an optical unit the light dispersing area is situated at the rear surface of the unit whereby an image projected at the front can be viewed from the rear of the unit.

The optical unit is so designed as to be selective in respect of projected light whilst not substantially impairing the intensity of the light serving to make the projected image visible, whether adapted for front or rear viewing. A further advantage is that the light dispersion device enables the screen image to be viewed from a wide angle.

Several practical embodiments of this invention will now be described, by way of example, with reference to the accompanying drawings in which:

Figure 1 is an elevation, partly in section, showing in schematic form the arrangement and mode of functioning of one form of optical unit having a spherical convex lens;

Figure 2 is a perspective view of a unit similar to Figure 1;

Figure 3 is a perspective view on a smaller scale of an assembly of these units constituting part of a projection screen;

Figure 4 is a perspective view of another form of optical unit with a cylindrical convex lens;

Figure 5 is a schematic side elevation showing another form of optical unit suitable for rear viewing;

Figure 6 is a view showing a group of optical units as shown in Figure 4 assembled to form part of a screen;

Figure 7 is a perspective diagram of a screen for explaining the effect of the "throw" of the projector on the shape of the reflecting surface of a unit;

Figure 7*a* is an enlarged perspective view of a detail of an optical unit for explaining the mode of making the screen shown in Figure 7;

Figure 8 is an enlarged perspective view of two optical units having cylindrical convex lenses;

Figure 9 is a perspective view of part of a screen formed by assembling a number of the units of Figure 8;

Figure 10 is a perspective view showing units based on those in Figure 4 assembled to form a screen;

Figure 11 is a perspective view of an assembly of four units forming part of a screen suitable for rear viewing;

Figure 12 is a perspective view showing part of another form of screen combining units based on the type in Figure 4;

Figure 13 is a schematic view showing the optical effect obtained by the use of the screens in Figures 11 and 12; and

Figure 14 is a side elevation of a modification of the optical unit of Figure 2.

Referring now to Figures 1, 2 and 3, an optical unit consists of an optically transparent rectangular section body 12, such as glass or plastic, having a rear mask surface 16 opposedly located in spaced relation to convex lens surface 14 at the front. The lens surface 14 is generally spherical in shape having a fixed radius of curvature and functions as a convex lens having an optical axis 18 and a focus (or focus zone) 20. The focus 20 is between the lens surface 14 and the rear mask surface 16, and the radius of curvature is determined so that the focus is near the rear mask surface.

The lens surface 14 has a small and generally circular light dispersion area 22 located on the optical axis 18, said area being formed by a substance which disperses light, for example bonded pellets of glass or plastics, translucent substance, or a light dispersing substance that is known in the art as frosted or ground glass.

In the present example, suitable for front viewing of the screen, there is formed a small and generally circular concave surface 24 in the rear mask portion 16, located on the optical axis 18 of the lens 14. This concave surface 24 is formed as a curved. e.g., spherical mirror 25, by coating with a highly reflecting substance such as optically

smooth silver or aluminium. The radius of curvature of the mirror is determined so that its focus is coincident with the focus 20 of the convex lens surface 14. Moreover, the concave mirror 25 has a value of $f$ which is the same value as that of convex lens surface 14. The radii of curvature of the lens surface 14 and the concave mirror 25 are in the same proportion as the respective focal lengths. The remaining portion of the rear mask 16, i.e., surface 16 other than the concave mirror surface 24 is totally coated with opaque substance which absorbs light, such as black paint. An assembly of optical units 10 to form a projection screen is made by suitably assembling them as in Figure 3 so that the lenses 14 form a generally plane image surface 26.

With reference to Figure 1, when a ray of light as indicated by the arrow 30 is incident upon the lens surface 14 in a direction parallel to the optical axis 18, it is refracted to converge at focus 20. The light ray 30 then strikes the concave mirror 25. Since the concave mirror 25 has its focus, or focus zone, 27 coincident with the focus 20, the light 30 is reflected parallel to the axis as at 32 on to the light dispersion portion 22 of the convex lens surface 14. When the reflected light ray 32 strikes the light dispersion portion 22, it is dispersed at the surface to diverge in many directions, as shown by the arrow 34.

A light ray shown at 36 incident upon the lens at an angle to the optical axis 18 is refracted by the lens surface away from the foci 20, 27 according to the particular angle of incidence upon the lens surface 14. Therefore, light ray 36 strikes the rear mask surface 16 and is absorbed thereat. The refracted ray 36, in its path, passes through a side wall 37 of the unit 10. If the units are aligned as in Figure 3, some of the refracted rays such as 36 will strike the concave mirror 25 of the adjacent unit, and will be reflected, thus lowering the efficiency of the screen.

In order to overcome this, the side surfaces 37 of each unit 10 parallel to the optical axis are coated with opaque light-absorbing substance, i.e. black paint to absorb the light rays 36. If a third light ray shown by the arrow 38 is incident upon the lens 14 at a slight inclination to the axis the ray refracted by the lens surface 14 strikes the concave surface mirror 25 and is reflected. However, since this refracted light 38 does not pass through the focus 27 of the concave mirror 25, it will not be reflected parallel to the axis and therefore does not strike the light dispersion portion 22. The amount of incident light represented by the rays 38 is of course in inverse proportion to the diameter of concave mirror 25. The concave mirror 25 is small, being positioned close to the focus 20. Also the focal length of the lens 14 should be at least several times of the focal length of the concave mirror 25 to achieve suitable selectivity of the unit in respect of the inclination of rays 38.

Referring to Figure 14, a concave mirror 25$a$ is suitably shaped so that reflected light 32$a$ can be concentrated on the lens surface 14$a$ at a small point. Thus, the light dispersion portion 22$a$ can be made as small as desired. The references in this figure, which correspond to those in Figures 1 and 2, are indicated by the suffix $a$ after the reference number.

It has been assumed in the foregoing that all the light incident upon a screen from the projector is incident upon each unit from the direction parallel to the optical axis. Each of the optical units of the screen should preferably have its optical axis directed towards the projector source, but this is not normally achieved.

This can be accomplished however by forming the screen as a spherical surface and placing the projector in its center of curvature, or by mounting each unit, if the screen is plane, so that the optical axis 18 of any unit is parallel to a line from the projector to said unit.

Referring to Figures 7 and 7$a$, which diagrammatically illustrate an optical unit 10$a$, located away from the projection axis 41 of a screen 40, and having its optical axis 18$a$ of convex lens 14$a$ positioned parallel to a projection light 43 from a projector positioned at point A. If the projector (not shown) is moved from point A to point B, the new projection line 45 to the unit is not parallel to the optical axis 18$a$ of the lens 14$a$. At the same time, a light ray 46 incident upon the lens surface 14$a$ in a direction parallel to the new projection line 45 refracts, when projector is at point B, not exactly to focus 20$a$ of body 10$a$ but rather to point 20$b$ slightly off focus.

Therefore, not all the light 46 incident upon the lens surface 14$a$ from the projector is directed towards the concave mirror 24$a$, but part of the light strikes a small crescent surface 47 shown shaded and is absorbed by a mask surface 16$a$. However, if the concave mirror is distorted from the circular to an elongated shape, (that is, in total, the area of the mirror 24$a$ and the small surface 47) then as the projector moves from point A to point B, substantially all the light 46 is directed to the concave mirror. However, when the concave surface mirror is of a shape and size necessary to receive the light 46, not all of the reflected light is reflected in a direction parallel to the optical axis 18$a$

of the lens $14a$, but some is reflected at an angle slightly inclined to the optical axis $18a$ so that in order to receive this light the light dispersion portion $22a$ must be formed of a somewhat oval shape similar to that of the concave mirror $24a$. Such formation of the concave mirror $24a$ and the light dispersion portion $22a$ causes the optical unit $10a$ to function effectively in any projector position between point A and point B, whilst only losing a negligible part of the projected light incident thereupon.

In view of the geometry, it is apparent that the degree of distortion and enlargement of the concave mirror $24a$ and the light dispersion portion $22a$ as described above will be in proportion to magnitude of displacement of each unit $10a$ from the optical axis 41 at the screen surface.

As each of the units functions individually as described above, the following method may be used to form the reflecting surfaces, e.g., the concave mirrors 24. The side surfaces 37 are coated with light absorbing substance before assembling the units into a screen formation. The rear mask surface 16 is applied and the reflection surfaces of the concave mirrors should be coated after all the units have been formed and assembled as a complete screen 40.

The concave surface 24 of the concave mirror 25 must in some cases be made larger than the area demanded by the geometry of a concave mirror of a unit situated exactly on the projecting axis. The mask surface 16, including the areas to be occupied by the mirrors, is coated with light-sensitive film or emulsion, and light is projected from the front on to the backed screen while the projector is moved from point A to point B in a dark room. The light sensitive substance senses the received light in each of the units at the areas where the mirror surfaces are required, for all positions of the projector between point A and point B. The activated areas of the light-sensitive substance are selectively removed in a known manner and silvered to form the concave mirror surfaces 25 of the shape and size required. If the rate of light absorption of the remaining areas of the backing is not sufficient, this backing material can be selectively removed and other light absorbing substances may be applied to produce the required selectivity of the units in respect of reflected light. The method is applicable also to the other embodiments described herein in which the units require to have a rear mirror surface to reflect selected light rays for front viewing of the projection screen.

Referring to Figure 4, a modified optical unit 50 according to the invention is shown. In this case the unit is again of generally parallelepiped form, like that in Figures 1-3, but differs in that the transparent body 52 is not square but of rectangular section, and has a convex cylindrical lens surface 54 whose generatrix is parallel to the longer dimension. The refraction surface 54 has an elongated focus 58 and an axial plane 59, in place of the focus 20 and optical axis 18 of the unit 10. The focus line 58, or focus zone, is again located within the unit body between the lens surface 54 and the rear mask surface 56, which, instead of having a generally circular mirror, is provided with an elongated linear slot or window 60. Within said slot there is provided a concave, preferably cylindrical, reflection surface 62 which has a linear focus which is in coincidence with the linear focus of the cylindrical lens 54.

The cylindrical lens 54 includes a portion 64 of light dispersing substance, said part being situated on the generatrix contained in the axial plane 59 and being of elongated linear shape similar to the slot or window 60. This shape of unit may be manufactured more easily than that shown in Figures 1 to 3. However, it has angular selectivity only in respect of light incident upon the cylindrical surface 54 in directions parallel to the axial plane 59. In a case of a screen formed by the cylindrical lens units shown in Figure 4, the units are aligned with the generatrix vertical as shown in Figure 6. In this mode, the unit has sufficient lateral, or horizontal selectivity, but no vertical selectivity. The side surfaces 57 of the unit 50 are again coated with light absorbing substance to prevent the passage of light rays into adjacent units through the side walls 57 and the possibility of such rays reflected by the reflection surfaces 62 of the adjacent units. The screen comprising units 50 should preferably be arranged so that the axial planes 59 of the unit bodies meet at the position of the projector. This may be achieved by a panoramically curved screen of the correct radius of curvature in horizontal planes.

In all cases as described above, each unit must not be made larger than an image element formed by projection. This is because an image as viewed is not an image converged at the screen but a combination of points or lines of light and appears in each unit of the screen in the form of a point or line.

Thus, if each unit is equal to the minimal image element which can be discriminated by the resolving power of the human eye, the quality of the image is never impaired. This magnitude is of course different depending upon the distance of viewing and the size of the screen.

Further, in order to allow for projec-

tion from a range of distances, as described in Figure 7, the size of the slot 60 of unit 50 is so chosen that the incident light 30 (as in Figure 1) is always reflected, notwithstanding that the direction of the light flux varies with different distances of projection. In this case the optimum dimensions and shape of the slot 60 and the concave mirror 62 may, of course, be determined as described in the foregoing discription with reference to Figures 7 and 7*a*.

In order to compensate for change of inclination of incident light 30 with change of projection distance, the optical unit can be formed and disposed as shown at 50 in Figure 10. In this case, in lieu of altering the shape of slot 60 or concave mirror 62 as in Figures 4 and 7, the unit 50 and its axial plane and focus line are radially extended outwardly from the central projection axis 41*a* of the screen 40*a*. If the unit body 50 is disposed as described, it is apparent that even if the projector is repositioned along the projection axis 41*a*, a line from the projector to each of unit bodies is always parallel to the focus line of each unit. Therefore, the path of light refracted by the lens of unit 50 is almost constant for any position of projector along the projection axis 41*a* so that it is not necessary to enlargen or to improve the shape of reflection surface for reflecting light on to the dispersion zone.

Figure 5 is a perspective view of an optical unit for use in a screen suitable for rear viewing. In this case, the image is projected from one direction (the front) and the image can be seen from the opposite direction (the back). The unit 70 has a square section body 72 made of optical transparent substance, having a lens surface 74 and a rear mask surface 76. The convex lens 74 is the same as the lens surface 14 as described referring to Figures 1 and 2 except that the curvature thereof is made so that the focus, or focal zone, 78 is coincident with the rear mask surface 76.

The mask surface 76 has an opaque film 77 of light absorbing substance. A bore or window 80 is formed in the mask surface 76, which is coaxially positioned with the optical axis 82 and which has size and shape corresponding to cross-section of the light flux striking the focus in the plane of the mask surface 76. The mask surface 76 is provided with a film 84 of light dispersing substance covering the bore or window 80.

Light rays 86 incident upon the lens surface in a direction generally parallel to the optical axis 82 are converged and cross at the focus 78 of the spherical lens 74. If the projector (not shown) is situated remote from the optical unit 70 as compared with the focal length of the lens surface 74, all the light striking the lens surface 74 from the projector may be regarded as parallel to the axis so that the lens 74 causes all the light 86 from the projector to be directed along lines through focus 78.

Further, since the bore 80 is transparent. light 86 passes therethrough and strikes the light dispersion portion 84 and diverges thereat. When the unit body is viewed from the rear (from the right as seen in Figure 5), light produced from the light dispersion portion 84 is consistent with the part of the image projected upon the lens surface 74.

Side illumination incident upon the lens surface 74 at an angle inclined to the optical axis 82 is refracted at the lens surface 74 but is not converged to focus 78 so that it does not pass through the bore 80 and is absorbed into light absorbing surface 76.

Similarly to the examples described referring to Figures 1 to 3, an optical unit shown in Figure 5 can be formed with a spherical lens, but it may instead have the cylindrical lens surface as shown in Figure 4. The side surface of the unit body may also be coated with light absorbing substance. In the case where the unit has a cylindrical lens, the bore 80 can be replaced by a slot of elongated shape. In order to compensate for movement of the projector along the optical axis of the screen, a wider bore 80, or a longer slot, may be employed so as to function as described above in a manner analogous to Figures 7 and 7*a*, or the bore 80 may be widened only in one direction.

In Figures 8 and 9, there is employed a rear viewing screen comprising two layers of cylindrical lens units 90 and 92, having a combined optical effect equivalent to the form of the invention shown in Figure 5, using a spherical lens. In this form, the rear layer of units of Figure 9 consists of unit bodies as shown in Figure 8, having a rear masked surface 96 similar to surface 76 of Figure 5, and a front cylindrical lens 94 similar to lens 74 of Figure 5.

The lens 94 has a curvature as described in the example shown in Figure 4 and has a corresponding linear focus 98. The masked surface 96 is made in accordance with the method described in Figure 5 and has a circular bore 104, similar to the bore 80 of Figure 5, in an opaque light absorbing layer 102 also similar to 77 of Figure 5, the bore being covered by a film 106 of light-dispersing substance.

Another cylindrical lens unit 90 is optically positioned in front of the unit body, so that the focus line 99 crosses at right angles the focus line 98 of the rear lens 94. Since the units 90 and 92 have their

cylindrical lens surfaces inclined at right angles to each other, light incident thereupon has optically the same effect as a spherical lens, for example 14 of the unit in Figures 1 to 3. Since the arrangement is for rear viewing, if units 92 and 90 are assembled as shown in Figure 9, an optical effect for rear viewing is obtained similar to that obtained by assembling units as shown in Figure 5.

Over the transparent bore 104 is arranged a light dispersion element 107. Further, the units 90 and 92 have the sides such as 108 coated with a light absorbing substance to prevent light from being transmitted from one unit to the adjacent units.

In the embodiments described above, each unit of the screen such as unit 10 in Figure 2 and unit 50 in Figure 4 has a film of light absorbing substance on the side surface wall of each unit so as to prevent light from being passed from one unit to adjacent units. The whole screen, or part thereof which is an assembly of a number of unit bodies, can be made by a simple mould. A suitable machine having a pattern mould of the screen may be used. However the manufacture of integral screens in such a manner requires a homogenous moulding substance, so that it is difficult to provide the side surface of each unit body with light absorbing film.

In order to overcome the foregoing difficulty, an integral assembly of units for a rear viewing screen can be manufactured as shown in Figures 11 to 13. Referring particularly to Figure 11, part of screen 110 comprises four units 112 shown by dotted lines. Although only four units are shown, it is evident that the same method may be used in combining as many units 112 as may be desired. Each piece 112 is equal to a unit as shown in Figure 2. However, instead of a mirror a rear mask surface 116 of each unit is provided with a cylindrical projection 118 coaxial with the optical axis 18*a* on the lens 14*a* and extending in a direction rearwardly of the mask surface. These projections 118 are integrally formed with the units 112 and are similarly made of optically transparent material. A light dispersing device 124*a* is formed at the end of each projection 118 as shown, which is positioned close to the focus 78*a* of the lens 14*a*. Each projection 118 has only its outer cylindrical wall coated with light absorbing substance, which is the same material as that used for the rear mask surface 116. Thus, the cylindrical wall of the projection 118 serves as a mask or trap for light in order to prevent the light, for example a ray 36a, passing through a side wall of an adjacent unit from striking the light dispersion coating 84*a* covering the end of the dispersing device 124*a*. The parallel rays, such as 86*a*, after refraction, strike the coating 84*a*.

As shown in Figure 12, in a similar embodiment employing a cylindrical lens each unit 120 has a projection 124 of square section extended rearwardly in symmetrical relation to the focus line 58*a* of said unit on the rear mask surface 122. Further, the side walls 126, 128 of square projection 124 are coated with light absorbing substance which serves as a mask. The end wall has a coating 62*a* of a light dispersing material. The optical unit body formed according to the invention has high selectivity in favour of light incident upon the lens surface in a direction parallel to the projection line from the projector to the unit and substantially rejects all the light obliquely incident upon said lens. For this reason, light incident upon the unit from the projector and striking the unit in a direction parallel to said projetcion line is again emitted from a concentrated dispersion area. Further since this light is concentrated into a small area it has a high intensity. At the same time, any surrounding light, such as from the sun, which strikes the unit at a predetermined angle of inclination to the projection line is absorbed by the screen. Therefore the projected image can be viewed, without affecting the quality, under the bright outdoor conditions such as sunlight.

The optical unit of the invention can easily be made of plastics material, both the lens surface and the concave mirror surface being produced by simple moulding opeartions. The mask surface can be applied by a simple coating operation.

WHAT I CLAIM IS:—

1. An optical projection screen comprising a number of similar elementary surface units, each unit comprising a transparent body, the front surface of which forms a convex lens surface, light absorbing means associated with the rear surface of said units, and a discrete area of light dispersing material individual to each unit, said area being coaxial with the lens and of small dimensions relative to the maximum cross sectional area of the unit normal to the lens axis, the arrangement being such that, for each individual unit, of all the incident projected light, only those rays which are initially incident upon each convex lens along lines substantially parallel to the optical axis will, after refraction, and subesequent reflection, strike said light dispersing area, whereby substantially all of the light from the screen as seen by an observer is emitted from said small dispersing areas whilst incident light entering the units at other angles is either absorbed by the light absorbing means or, if internally reflected, does not strike the dispersing areas.

2. An optical projection screen according to claim 1, wherein the thickness of said area of light dispersing material is many orders of magnitude less than the focal length of the convex lens surface.

3. An optical projection screen according to claim 1 or 2, in which the light-absorbing means comprises masking means contacting substantially the whole of the rear surface of said units except a restricted area coaxial with the lens axis in a position adjacent the focus region of said lens.

4. An optical screen according to claim 3 wherein said light-absorbing means further includes masking means covering at least one side surface of the units extending substantially parallel to the optical axis of the lens.

5. An optical screen according to any one of claims 1 to 4, wherein each unit, apart from the convex lens surface, is substantially of parallelepiped form, with plane side faces arranged to make contact with the side faces of adjacent units when assembled on the screen face.

6. An optical screen according to claim 5, wherein each unit has a spherical convex lens surface and is otherwise of square section across the optical axis.

7. An optical screen according to claim 5, wherein each unit has a cylindrical convex lens surface and is otherwise of rectangular cross section with the major dimension of said rectangle parallel to the cylinder generatrix.

8. An optical screen according to claim 5, 6 or 7, each unit having a reflecting mirror on the optical axis adjacent the focal area of the lens, and a coaxial light dispersing area on the lens surface, said mirror reflecting said rays incident upon said lens surface substantially parallel to said optical axis back along said optical axis on to the dispersing area so that said dispersing area is visible from the projection side of the screen.

9. An optical screen according to claim 8 as dependent on claim 6, wherein the mirror is a concave spherical mirror.

10. An optical screen according to claim 8 as dependent on claim 7, wherein the mirror is the internal surface of a central longitudinal slot at the rear surface of the unit, and the light dispersing area contains a generatrix of the cylindrical lens intersecting the optical axis of the lens.

11. An optical screen according to claim 8 or 9, wherein the radii of curvature of the lens and the reflecting mirror are in the same proportion as their respective focal lengths.

12. An optical screen according to claim 8 or 9, wherein the light dispersing area of the lens is of substantially similar dimensions to the reflecting area, and the reflecting area returning the selected light rays in a direction parallel to the optical axis to strike said light dispersing area.

13. An optical screen according to claim 9, wherein the rays reflected by the mirror are concentrated on a coaxial dispersing area smaller than the area of the mirror.

14. An optical screen according to any one of claims 1 to 7, wherein said light dispersing area is situated behind an aperture in the light absorbing means at the rear surface of each unit whereby an image projected on to said front surface can be viewed through said rear surface.

15. An optical screen according to claim 14, wherein the light dispersing area is the internal surface of a film of light dispersing substance covering said aperture in the light absorbing means, said aperture being substantially coterminous with the focal area of the lens.

16. An optical projection screen according to claim 14 as dependent on claim 3, wherein the light dispersing area of each unit is situated on a projection extending rearwardly of the rear surface of the unit, the side walls of said projection being covered by masking means and the end surface thereof being the light dispersing area.

17. A projection screen according to any preceding claim except claim 3 and claims dependent thereon, comprising a plurality of optical units assembled and secured together such that all the convex lens surfaces are aligned to form the front surface of the screen, the rear surface of which is covered by a continuous light-absorbing masking sheet.

18. A projection screen for rear viewing according to claim 7, or any claim dependent thereon, said units being assembled in two superimposed layers, the rear layer having the cylindrical convex lens generatrices directed at right angles to the generatrices of the front layer of cylindrical lenses.

19. A projection screen according to any of claims 1 to 18, wherein the front surface of the screen is a concave spherical surface with a radius of curvature corresponding to the predetermined projection distance in front of the screen.

20. A method of making a projection screen as claimed in any preceding claim, including moulding a plurality of said surface units integrally in a mould and applying masking means to the rear surface of the moulded body.

21. A method of making a projection screen arranged for front viewing and according to claim 8 or 9, comprising the steps of arranging said units on a support with a mask material carrying a light sensitive coating covering the rear surfaces of said units, exposing said coating by projecting light from a projector whilst moving the projector between predetermined projection positions in front of the assembly of units,

removing the light sensitized areas of said coating and depositing thereon a reflecting coating to form the reflecting mirror surfaces of the respective units at individual positions on said mask material.

22. Projection screens comprising assemblies of optical units substantially as hereinbefore described with reference to the examples illustrated in the accompanying drawings.

23. Methods of making projection screens substantially as hereinbefore described with reference to the accompanying drawings.

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1 440 016 COMPLETE SPECIFICATION
3 SHEETS This drawing is a reproduction of the Original on a reduced scale.
SHEET 1

Fig. 1

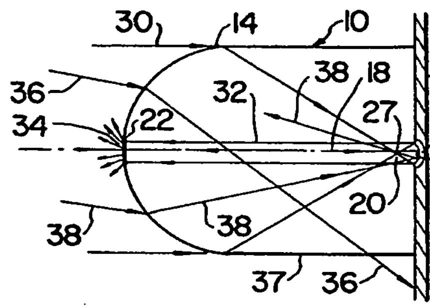
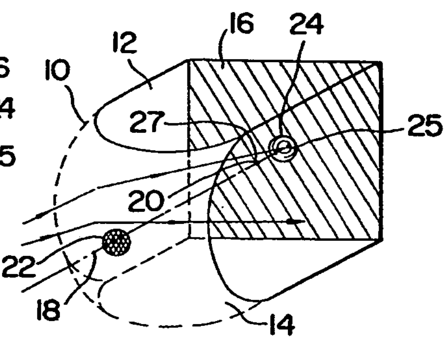



Fig. 2



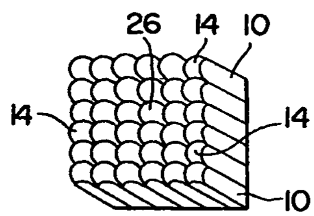




Fig. 3

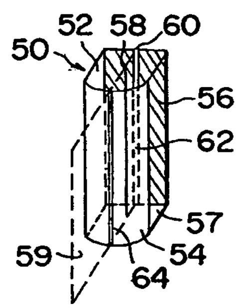



Fig. 4

Fig. 5

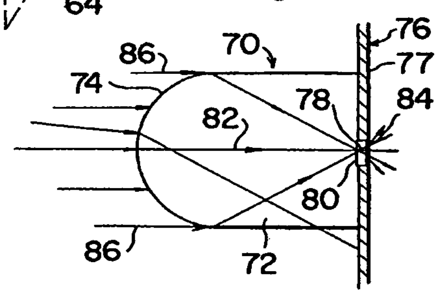
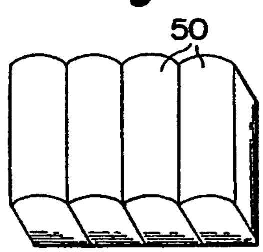



Fig. 6



1 440 016 COMPLETE SPECIFICATION
3 SHEETS
*This drawing is a reproduction of the Original on a reduced scale.*
SHEET 2

**Fig.7a**

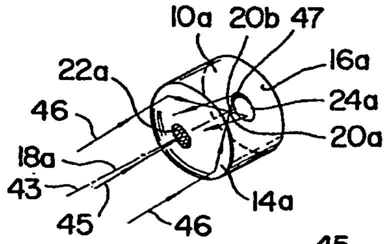



**Fig.7**

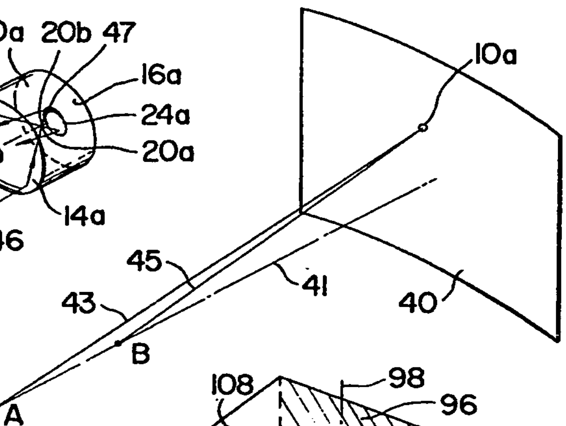



**Fig.8**

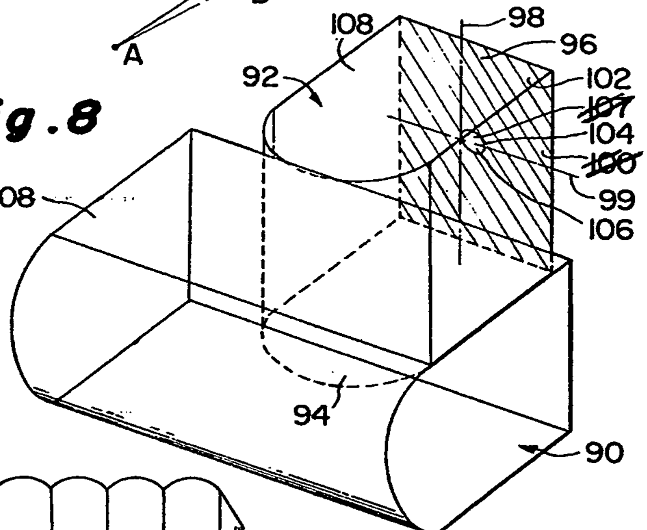
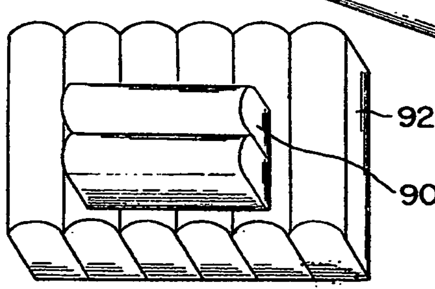



**Fig.9**



1 440 016 COMPLETE SPECIFICATION

*3 SHEETS* *This drawing is a reproduction of the Original on a reduced scale.*

*SHEET 3*

**Fig. 11**

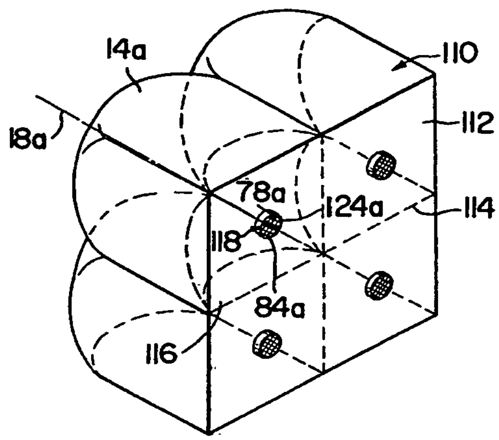



**Fig. 12**

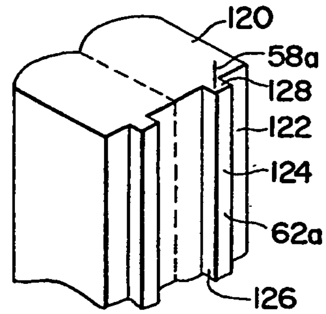



**Fig. 10**

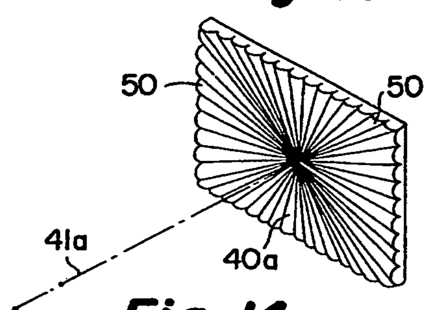



**Fig. 13**

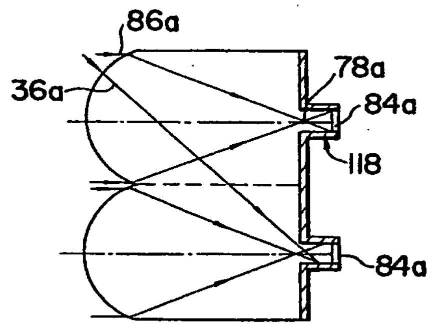



**Fig. 14**